



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Appl. of: Robert J. SMALL and Zhefei J. CHEN. Confirmation No: 1702
Serial No: 10/057,206 Group: 1755
Filed: January 25, 2002 Examiner: M. Marcheschi
Entitled: **COMPOSITIONS FOR CHEMICAL-MECHANICAL PLANARIZATION OF NOBLE-METAL-FEATURED SUBSTRATES, ASSOCIATED METHODS, AND SUBSTRATES PRODUCED BY SUCH METHODS** ATTY DOCKET: 063254-5002-US

DECLARATION OF ROBERT J. SMALL UNDER 37 C.F.R. § 1.131

I, ROBERT J. SMALL, declare under the penalty of perjury as set forth below:

1. I am a co-inventor named in the above-referenced patent application 10/057,206 which was filed on January 25, 2002 ("Application").
2. I was employed by EKC Technology, Inc., the original Assignee ("Assignee") of the Application by virtue of an assignment recorded in the U.S. Patent Office at Reel 12540 and Frame 0635. As part of the work for EKC, I developed compositions for polishing a substrate having a noble metal material, or a material comprising a noble metal, on its surface. The compositions comprised periodic acid, or H_5IO_6 , which was often referred to as "PIA" and which is referred to hereinafter as PIA, and an abrasive. Portions of this work are the subject matter disclosed in the Application and are the subject matter of claims 77-106 and 108-139 that are pending in this Application.
3. Pending claims 77-106 and 108-139 stand rejected in view of: Brusic (USP 6,527,622, which issued on March 4, 2003, from an application filed on January 22, 2002) in view of Fang '227 (USP 6,461,227 from an application filed October 17, 2000) or Dirksen (published application 2002/0076932, from an application filed December 15, 2000, and which claims priority to a provisional application filed on December 17, 1999).
4. The rejections under one or more of Shemo '774 (USP 6,328,774 from an application filed February 23, 2000), Shemo '831 (USP 6,332,831 from an application filed April 6, 2000), Fang (USP 6,461,227 from an application filed October 17, 2000), Streinz (USP 5,993,686 from an application filed June 6, 1996), Kaufman (USP 6,063,306 from an application filed June 26, 1998), and Tredinnick (published application 2002/0125460 from an application

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filed January 9, 2001) have been withdrawn by the Examiner. During the year 2001, a number of discussions and documents containing information pertaining to the inventions disclosed in the Application, which are the subject matter of claims 77-106 and 108-139 that are pending in this Application, were conducted with and provided to Mr. Dennis A. DeBoo, a registered patent agent, for the purpose of assisting Mr. DeBoo in preparing a first draft of the application which has matured into the Application.

5. Attached hereto is a transmittal letter from Mr. DeBoo to myself dated July 24, 2001, and selected pages 1-11, 14-23, and 32-35 of a draft application entitled "Compositions for Nobel Metal Chemical-Mechanical Planarization Processes" having a total of 45 numbered pages and also being dated July 24, 2001, which describe at least a portion of the invention which was known to the inventors at that time. Applicants worked diligently from July 24, 2001 until the filing date of the Application to make revisions to the draft application which was eventually by those revisions transformed into the Application.

6. Documentary evidence that the Inventors were in possession of the invention on or before July 24, 2001, can be found on pages 1-2 and in the Examples described on pages 1-11, 14-23, and 32-35 of the draft application dated July 24, 2001.

a) Example A on pages 3-5 describe use of a slurry having 2% alumina abrasive and 0.1 mol/kg PIA (at a pH between 1.5 and 2.5) to polish Ir at removal rates from 288, 375, and 400 angstroms/minute (using various polishing conditions).

b) Example B on pages 5-7 describe use of a slurry having 2% alumina abrasive and 0.1 mol/kg PIA and adjusted with TMAH to a pH between 6 and 7 to polish Ir at a removal rate of 325 angstroms/minute.

c) Example C on pages 7-9 describe use of a slurry having 2% alumina abrasive and 0.1 mol/kg PIA and adjusted with ammonium hydroxide to a pH of 6-7, preferably about 7, to polish Ir at a removal rate of 360 angstroms/minute.

d) Example D on pages 9-11 describe use of a slurry having 2% alumina abrasive and 0.1 mol/kg PIA and adjusted with ammonium hydroxide to a pH of about 3, to polish Ir at a removal rate of 320 angstroms/minute and having a Ir to dielectric selectivity of 1:1.5.

e) Example G on pages 15-16 describe a slurry comprising $12.5 \times 0.16 = 2\%$ alumina abrasive, a small amount of a second abrasive Darvan™ C, 2.3% PIA, adjusted to pH ~7 and used to polish Ir at 340 angstroms/minute (see page 22).

f) Example F, G, H, I, and K on pages 14-23 describe slurries comprising alumina abrasive and 2.3% PIA wherein on polishing wafers the selectivity to the noble metal Ir over the dielectric was between 2.1:1 to 3.9:1.

g) Example I on pages 18-19 describe a slurry comprising 12.5x0.16= 2% alumina abrasive, a small amount of a Etcarbonate™ abrasive, 2.3% PIA, adjusted to pH ~7 and used to polish Ir at 350 angstroms/minute.

h) Example O (208) on pages 32-34 describe use of a slurry having 2% alumina abrasive, 0.1 mol/kg PIA, and 0.1 mol/kg ammonium chloride to polish platinum at 443 angstroms/minute.

i) Example P(208a) on pages 34-35 describe use of a slurry having 6% alumina abrasive, 0.1% PIA, and 0.1% ammonium chloride to polish platinum at rates between 220 and 1020 angstroms/minute.

7. The submissions previously made in the declarations filed in the prosecution of this application are incorporated into this declaration, in particular the information in the June 16, 2004 declaration by the undersigned including copies of notebook pages (unnecessary portions of which were redacted) concerning the chemical-mechanical polishing of noble metals, are incorporated herein by reference thereto, including specifically the page appended to the laboratory notebook of Z. Chen, in Appendix 4 information in the June 16, 2004 declaration, showing use of slurries containing 2% or 4% abrasive and either 0.1 or 0.2 mole/kilogram of PIA and exhibiting Ir removal rates of greater than 300 angstroms per minute.

8. In view of the foregoing, I believe the invention as reflected in independent claims 77, 94, and 112, reproduced below, were conceived and reduced to practice before July 24, 2001.

Claim 77. A combination of a chemical mechanical polishing composition in contact with a substrate surface having at least one feature thereon comprising a noble metal, said combination comprising: a substrate comprising submicron integrated circuits and having a surface having at least one feature thereon comprising a noble metal; said substrate surface contacting a chemical mechanical polishing composition comprising: periodic acid and an abrasive in a combined amount sufficient to render the substrate surface substantially planar and to maintain a polishing rate of between 300 Angstroms per minute to about 2000

Angstroms per minute upon chemical-mechanical polishing thereof, wherein periodic acid is in an amount from about 0.05 to about 0.3 moles/kilogram.

Claim 94. A combination of a chemical mechanical polishing composition in contact with a substrate surface having at least one feature thereon comprising a noble metal comprising: a substrate having a surface, wherein said surface a dielectric material and has at least one feature thereon comprising a noble metal, and wherein said surface is contacting a composition comprising:

periodic acid in an amount from about 0.05 to about 0.3 moles/kilogram; and
an abrasive in an amount from about 0.2 to about 6 weight percent, said composition having a pH selected from a group consisting of a pH from about pH 1 to less than pH 2 and a pH from above pH 5 to about pH 10; and wherein on polishing the substrate surface with the composition contacting the surface the selectivity of the composition for polishing the noble metal-containing material over polishing the dielectric material is at least 1:1.

Claim 112. A combination of a composition in contact with a substrate surface having at least one feature thereon comprising a noble metal, comprising:

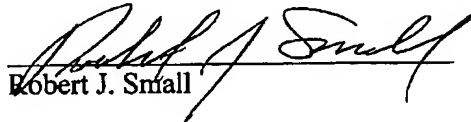
A) a composition consisting essentially of:

- 1) water;
- 2) periodic acid in an amount from about 0.05 to about 0.3 moles/kilogram;
- 3) a first alumina abrasive in an amount from about 0.2 to about 6 weight percent;
- 4) optionally, a pH-adjusting agent in an amount sufficient to cause the pH of the slurry to be between about 1 to about 4 or between about 5 to about 10;
- 5) optionally, a suspension agent; and
- 6) optionally, an electrolyte, wherein said composition is contacting a substrate surface having at least one feature thereon comprising a noble metal.

9. I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the

United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Dated: November 14, 2005


Robert J. Small

Compositions for Nobel Metal Chemical-Mechanical Planarization Processes

FIELD OF THE INVENTION

The present invention relates generally to compositions for Nobel Metal chemical mechanical planarization or polishing processes and, in particular, to compositions for chemical mechanical planarization or polishing processes of Nobel Metals such as Ir and Pt and their oxides.

BACKGROUND OF THE INVENTION

Chemical mechanical planarization (CMP) or polishing processes are well established for modern semiconductor interconnect technology employing metals such as W, Cu and Al. In stark contrast, only very little is known so far about CMP processes of noble metals or noble metal alloys, for example, Au, Ag and the group VIII metals of the periodic table such as Pt and Ir, and their oxides. However, interest in these metals is gaining momentum since they are used as electrodes and barrier materials in Gigabit DRAMs and FeRAMs.

Semiconductor companies, world-wide, are making efforts to commercialize high dielectric constant and ferroelectric thin films in, for example, advanced DRAMs and ferroelectric random access memories (FeRAMs), respectively. These materials include BaSrTiO₃ (BST) for forming capacitors dielectrics (DRAM storage capacitors or coupling capacitors in general circuits) in submicron integrated circuits because of their high dielectric constant. Additionally, materials such as PbZrTiO₃ (PZT) and SrBi₂Ti₂O₉ (SBT) that can store charge permanently are employed in the formation of non-volatile FeRAM memory. The chemical properties of BaSrTiO₃, PbZrTiO₃, and SrBi₂Ti₂O₉ require that they be used with noble metals or noble metal alloys such as Pt, Ir, IrO₂, et cetera.

However, conventional patterning of these materials by dry etching processes has faced considerable difficulties such as taper angle, fence formation, and residual particles leading to contamination. Some fundamental difficulties of conventional dry etching processes are due to the predominantly physical (not chemical) mechanism for material removal thereby resulting in formation of unwanted structures at the edges of the electrodes.

For the forgoing reasons, there is a need for new, novel and useful chemical compositions for chemical mechanical planarization or polishing processes of Nobel Metal or group VIII metals of the periodic table such as Pt and Ir and their oxides, for example, IrO_2 . Furthermore, there is a need for new, novel and useful chemical compositions for planarization or polishing of Nobel Metals that are compatible with standard chemical mechanical planarization or polishing equipment. Furthermore, there is a need for CMP slurry compositions that polish Nobel Metals at desired high polishing rates while minimizing surface imperfections, defects, corrosion, recessing and erosion.

Description

Ir Polishing Compositions

Composition A

One preferred Ir polishing composition pursuant to the present invention ("Composition A") is comprised of an alpha-alumina abrasive, Periodic Acid (H_5IO_6), and de-ionized ("DI") water. One example of component concentrations for Composition A is shown in the following table.

Composition A Component Concentration

Component	Component Concentration
Alpha-Alumina Abrasive (CR30)	2 wt%
Periodic Acid	0.1mol/kg
DI Water	Remaining weight amount to obtain final desired amount of Composition A

Thus, for example, 10 kilograms of Composition A requires 200 grams of alpha-alumina abrasive plus 1 mole of Periodic Acid and the remaining amount DI water.

pH Ranges

Composition A may have a general pH range of less than or equal to about 2.5 and a preferred pH of about 1.5.

Preparation

Generally, Composition A is prepared by first preparing a container of DI water to which the alpha-alumina abrasive (CR30) is added and then the Periodic Acid (H_5IO_6) is added.

Composition A is preferably continuously stirred within the container during at least the composition preparation.

CMP Process:

The following table shows one example of the mixing ratio, process, pH and removal rate for Composition A.

Mixing Ratio, Process, pH and Removal Rate

Mixing Ratio	Process	pH	Ir Removal Rate (A/min)
2 wt% Alpha-Alumina Abrasive 0.1mol/1kg Periodic Acid DI water	4/0/50/51/150	1.5 – 2.5	288

In the above example, the CMP process was carried out on IPEC's AVANTI 472 polisher and was achieved by applying a down force pressure of 4 psi, a back pressure of 0 psi, a table speed of 50 rpm, a carrier speed of 51 rpm, and a composition flow rate of 150 ml/min. A stacked pad of IC-1000 over Suba 4 was used as the polishing pad on the primary platen of the polisher and a polytex pad was used as the buff pad on the secondary platen of the polisher. Composition A was stirred thoroughly before and during its use.

Composition A, when employed according to the above process, provided an Ir removal rate of approximately 288 angstroms per minute.

Additionally, Composition A achieved an Ir removal rate of approximately 375 angstroms per minute when carried out according to the above process with the exception of increasing the down force pressure from 4 psi to a down force pressure of 6 psi. Furthermore, Composition A achieved an Ir removal rate of approximately 400 angstroms per minute when carried out according to the above process with the exception of increasing the table speed from 50 rotations per minute to 70 rotations per minute.

Ir Polishing Compositions Including Titration with TMAH

Composition B

Another preferred Ir polishing composition pursuant to the present invention ("Composition B") is comprised of an alpha-alumina abrasive, Periodic Acid (H_5IO_6), de-ionized ("DI") water, and a base in the form of Tetramethylammonium Hydroxide (TMAH). One example of component concentrations for Composition B is shown in the following table.

Composition B Component Concentration

Component	Component Concentration
Alpha-Alumina Abrasive (CR30)	2 wt%
Periodic Acid	0.1mol/kg
DI Water	Remaining weight amount to obtain final desired amount of Composition B
Tetramethylammonium Hydroxide (TMAH)	Titrate with TMAH to a pH of approximately between 6 and 7

For example, 10 kilograms of Composition B requires 200 grams of alpha-alumina abrasive plus 1 mole of Periodic Acid and the remaining amount DI water. This chemistry is then titrated with TMAH to obtain a final pH of about 6 to about 7.

pH Ranges

Composition B may have a general pH range of about 6 to about 7 and a preferred pH of about 7.

Preparation

Generally, Composition B is prepared by first preparing a container of DI water to which the alpha-alumina abrasive (CR30) is added. Next, the Periodic Acid (H_5IO_6) is added. This chemistry is then titrated with TMAH to obtain a final pH value of about 6 to about 7. Composition B is preferably continuously stirred within the container during at least the composition preparation.

CMP Process:

The following table shows one example of the mixing ratio, process, pH and removal rate for Composition B.

Mixing Ratio, Process, pH and Removal Rate

Mixing Ratio	Process	pH	Ir Removal Rate (A/min)

2 wt% Alpha-Alumina Abrasive	4/0/50/51/150	6-7	325
0.1mol/1kg Periodic Acid			
DI water			
Titrate with TMAH to a pH of approximately 7			

In the above example, the CMP process was carried out on IPEC's AVANTI 472 polisher and was achieved by applying a down force pressure of 4 psi, a back pressure of 0 psi, a table speed of 50 rpm, a carrier speed 51 rpm, and a composition flow rate of 150 ml/min. A stacked pad of IC-1000 over Suba 4 was used as the polishing pad on the primary platen, and a polytex pad was used as the buff pad on the secondary platen. Composition B was stirred thoroughly before and during its use.

Composition B, when employed according to the above process, provided an Ir removal rate of approximately 325 angstroms per minute.

Ir Polishing Compositions Including Titration with NH_4OH

Composition C

Another preferred Ir polishing composition pursuant to the present invention ("Composition C") is comprised of an alpha-alumina abrasive, Periodic Acid (H_5IO_6), de-ionized ("DI") water, and a base in the form of Ammonium Hydroxide (NH_4OH). One example of component concentrations for Composition C is shown in the following table.

Composition C Component Concentration

Component	Component Concentration
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Alpha-Alumina Abrasive (CR30)	2 wt%
Periodic Acid	0.1mol/kg
DI Water	Remaining weight amount to obtain final desired amount of Composition C
Ammonium Hydroxide (NH ₄ OH)	Titrate with NH ₄ OH to a pH of approximately 7

For example, 10 kilograms of Composition C requires 200 grams of alpha-alumina abrasive plus 1 mole of Periodic Acid and the remaining amount DI water. This chemistry is then titrated with NH₄OH to obtain a final pH of about 6 to about 7.

pH Ranges

Composition C may have a general pH range of about 6 to about 7 and a preferred pH range of about 7.

Preparation

Generally, Composition C is prepared by first preparing a container of DI water to which the alpha-alumina abrasive (CR30) is added. Next, the Periodic Acid (H₅IO₆) is added. This chemistry is then titrated with NH₄OH to obtain a final pH value of about 7. Composition C is preferably continuously stirred within the container during at least the composition preparation.

CMP Process:

The following table shows one example of the mixing ratio, process, pH, removal rate and selectivity for Composition C.

Mixing Ratio, Process, pH, Removal Rate, and Selectivity

Mixing Ratio	Process	pH	Ir Removal Rate (A/min)	Ir:TEOS Selectivity
2 wt% Alpha-Alumina Abrasive 0.1mol/1kg Periodic Acid Remaining % DI water Titrate with NH ₄ OH to a pH of approximately 7	5/0/90/50/150	6 - 7	360	1.8:1

In the above example, the CMP process was carried out on IPEC's AVANTI 472 polisher and was achieved by applying a down force pressure of 5 psi, a back pressure of 0 psi, a table speed of 90 rpm, a carrier speed 50 rpm, and a composition flow rate of 150 ml/min. A stacked pad of IC-1000 over Suba 4 was used as the polishing pad on the primary platen, and a polytex pad was used as the buff pad on the secondary platen. Composition C was stirred thoroughly before and during its use.

Composition C, when employed according to the above process, provided an Ir removal rate of approximately 360 angstroms per minute and an Ir:TEOS selectivity of 1.8:1.

Composition D

Another preferred Ir composition pursuant to the present invention ("Composition D") is comprised of an alpha-alumina abrasive, Periodic Acid (H₅IO₆), de-ionized ("DI") water, and a

base in the form of Ammonium Hydroxide (NH_4OH). One example of component concentrations for Composition D is shown in the following table.

Composition D Component Concentration

Component	Component Concentration
Alpha-Alumina Abrasive (CR30)	2 wt%
Periodic Acid	0.1mol/1kg
DI Water	Remaining weight amount to obtain final desired amount of Composition D
Ammonium Hydroxide (NH_4OH)	Titrate with NH_4OH to a pH of approximately 3

For example, 10 kilograms of Composition D requires 200 grams of alpha-alumina abrasive plus 1 mole of Periodic Acid and the remaining amount DI water. This chemistry is then titrated with NH_4OH to obtain a final pH of about 3.

pH Ranges

Composition D may have a general pH range of about 2 to about 4 and a preferred pH range of about 3.

Preparation

Generally, Composition D is prepared by first preparing a container of DI water to which the alpha-alumina abrasive (CR30) is added. Next, the Periodic Acid (H_5IO_6) is added. This

chemistry is then titrated with NH_4OH to obtain a final pH value of about 3. Composition D is preferably continuously stirred within the container during at least the composition preparation.

CMP Process:

The following table shows one example of the mixing ratio, process, pH, removal rate and selectivity for Composition D.

Mixing Ratio, Process, pH, Removal Rate and Selectivity

Mixing Ratio	Process	pH	Ir Removal Rate (A/min)	Selectivity
2 wt% Alpha-Alumina Abrasive 0.1mol/1kg Periodic Acid Remaining % DI water Titrate with NH_4OH to a pH of approximately 3	5/0/90/50/150	3 - 4	320	1:1.5

In the above example, the CMP process was carried out on IPEC's AVANTI 472 polisher and was achieved by applying a down force pressure of 5 psi, a back pressure of 0 psi, a table speed of 90 rpm, a carrier speed 50 rpm, and a composition flow rate of 150 ml/min. A stacked pad of IC-1000 over Suba 4 was used as the polishing pad on the primary platen, and a polytex pad was used as the buff pad on the secondary platen. Composition D was stirred thoroughly before and during its use.

In the above example, the CMP process was carried out on IPEC's AVANTI 472 polisher and was achieved by applying a down force pressure of 5 psi, a back pressure of 0 psi, a table speed of 90 rpm, a carrier speed of 50 rpm, and a composition flow rate of 150 ml/min. A stacked pad of IC-1000 over Suba 4 was used as polishing pad on the primary platen, and a polytex pad was used as the buff pad on the secondary platen. Composition E was stirred thoroughly before and during its use.

Composition E, when employed according to the above process, provided an Ir removal rate of approximately 260 angstroms per minute and an Ir:TEOS selectivity of 1:2.2.

Composition F

Another preferred Ir polishing composition pursuant to the present invention ("Composition F") adds a second abrasive to Composition C for making a better suspension. In one preferred form, the second abrasive is Laponite. One example of component concentrations for Composition F is shown in the following table.

Composition F Component Concentration

Component	Component Concentration
Periodic Acid	2.3 grams
DI Water	76 grams
Ammonium Hydroxide (NH ₄ OH)	Titrate the above components with NH ₄ OH to a pH of approximately 7
DI Water	8 grams
Laponite	0.5 grams

(Second Abrasive)	
Alpha-Alumina Abrasive (CR30 @ 16wt%) (First Abrasive)	12.5 grams

Preparation

In one form, Composition F is prepared by preparing a container of DI water (76 grams) to which the Periodic Acid (H_5IO_6) is added. This chemistry is then titrated with NH_4OH to a final pH value of about 7 thereby defining an oxidizer (Oxidizer "A"). Next, the Laponite (the second abrasive) and the alpha-alumina (the first abrasive) are added to eight grams of DI water thereby defining an abrasive (Abrasive "A"). Oxidizer A is then added to Abrasive A for completing the preparation of Composition F. Continuous stirring is maintained during at least the composition preparation.

Composition G

Another preferred Ir polishing composition pursuant to the present invention ("Composition G") adds a second abrasive in the form of Darvan C to Composition C for making a better suspension. One example of component concentrations for Composition G is shown in the following table.

Composition G Component Concentration

Component	Component Concentration
Periodic Acid	2.3 grams
DI Water	76 grams

Ammonium Hydroxide (NH ₄ OH)	Titrate the above components with NH ₄ OH to a pH of approximately 7
DI Water	8 grams
Darvan C (Second Abrasive)	0.5 grams
Alpha-Alumina Abrasive (CR30 @ 16wt%) (First Abrasive)	12.5 grams

Preparation

In one form, Composition G is prepared by preparing a container of DI water (76 grams) to which the Periodic Acid (H₅IO₆) is added. This chemistry is then titrated with NH₄OH to a final pH value of about 7 thereby defining an oxidizer (Oxidizer "A"). Next, the Darvan C (the second abrasive) and the alpha-alumina (the first abrasive) are added to eight grams of DI water thereby defining an abrasive (Abrasive "B"). Oxidizer A is then added to Abrasive B for completing the preparation of Composition G. Continuous stirring is maintained during at least the composition preparation.

Composition H

Another preferred Ir polishing composition pursuant to the present invention ("Composition H") adds a second abrasive to Composition C for making a better suspension. In another preferred form, the second abrasive is Ludox TM50. One example of component concentrations for Composition H is shown in the following table.

Composition H Component Concentration

Component	Component Concentration
Periodic Acid	2.3 grams
DI Water	76 grams
Ammonium Hydroxide (NH ₄ OH)	Titrate the above components with NH ₄ OH to a pH of approximately 7
DI Water	8 grams
Ludox TM50 (Second Abrasive)	0.5 grams
Alpha-Alumina Abrasive (CR30 @ 16wt%) (First Abrasive)	12.5 grams

Preparation

In one form, Composition H is prepared by preparing a container of DI water (76 grams) to which the Periodic Acid (H₅IO₆) is added. This chemistry is then titrated with NH₄OH to a final pH value of about 7 thereby defining an oxidizer (Oxidizer "A"). Next, the Ludox TM50 (the second abrasive) and the alpha-alumina (the first abrasive) are added to eight grams of DI water thereby defining an abrasive (Abrasive "C"). Oxidizer A is then added to Abrasive C for completing the preparation of Composition H. Continuous stirring is maintained during at least the composition preparation.

Composition I

Another preferred Ir polishing composition pursuant to the present invention ("Composition I") adds a second abrasive to Composition C for making a better suspension. In another preferred form, the second abrasive is EtCarbonate. One example of component concentrations for Composition I is shown in the following table.

Composition I Component Concentration

Component	Component Concentration
Periodic Acid	2.3 grams
DI Water	76 grams
Ammonium Hydroxide (NH ₄ OH)	Titrate the above components with NH ₄ OH to a pH of approximately 7
DI Water	8 grams
EtCarbonate (Second Abrasive)	0.5 grams
Alpha-Alumina Abrasive (CR30 @ 16wt%) (First Abrasive)	12.5 grams

Preparation

In one form, Composition I is prepared by preparing a container of DI water (76 grams) to which the Periodic Acid (H₅IO₆) is added. This chemistry is then titrated with NH₄OH to a final pH value of about 7 thereby defining an oxidizer (Oxidizer "A"). Next, the EtCarbonate

(the second abrasive) and the alpha-alumina (the first abrasive) are added to eight grams of DI water thereby defining an abrasive (Abrasive "D"). Oxidizer A is then added to Abrasive D for completing the preparation of Composition I. Continuous stirring is maintained during at least the composition preparation.

Composition J

Another preferred Ir polishing composition pursuant to the present invention ("Composition J") adds a second abrasive to Composition C for making a better suspension. In another preferred form, the second abrasive is Succinic acid. One example of component concentrations for Composition J is shown in the following table.

Composition J Component Concentration

Component	Component Concentration
Periodic Acid	2.3 grams
DI Water	76 grams
Ammonium Hydroxide (NH ₄ OH)	Titrate the above components with NH ₄ OH to a pH of approximately 7
DI Water	7.5 grams
Succinic acid (Second Abrasive)	1.0 grams
Alpha-Alumina Abrasive (CR30 @ 16wt%) (First Abrasive)	12.5 grams

Preparation

In one form, Composition J is prepared by preparing a container of DI water (76 grams) to which the Periodic Acid (H_5IO_6) is added. This chemistry is then titrated with NH_4OH to a final pH value of about 7 thereby defining an oxidizer (Oxidizer "A"). Next, the Succinic acid (the second abrasive) and the alpha-alumina (the first abrasive) are added to 7.5 grams of DI water thereby defining an abrasive (Abrasive "E"). Oxidizer A is then added to Abrasive E for completing the preparation of Composition J. Continuous stirring is maintained during at least the composition preparation.

Composition K

Another preferred Ir polishing composition pursuant to the present invention ("Composition K") adds a second abrasive to Composition C for making a better suspension. In another preferred form, the second abrasive is an Alpha-Alumina Abrasive in the form of CR140. One example of component concentrations for Composition K is shown in the following table.

Composition K Component Concentration

Component	Component Concentration
Periodic Acid	2.3 grams
DI Water	76 grams
Ammonium Hydroxide (NH_4OH)	Titrate the above components with NH_4OH to a pH of approximately 7
DI Water	3.5 grams

CR140 @ 20 wt% (Second Abrasive)	5.0 grams
Alpha-Alumina Abrasive (CR30 @ 16 wt%) (First Abrasive)	12.5 grams

Preparation

In one form, Composition K is prepared by preparing a container of DI water (76 grams) to which the Periodic Acid (H_5IO_6) is added. This chemistry is then titrated with NH_4OH to a final pH value of about 7 thereby defining an oxidizer (Oxidizer "A"). Next, CR140 (the second abrasive) and CR30 (the first abrasive) are added to 3.5 grams of DI water thereby defining an abrasive (Abrasive "F"). Oxidizer A is then added to Abrasive F for completing the preparation of Composition K. Continuous stirring is maintained during at least the composition preparation.

The following table summarizes preparation conditions for Compositions F through K.

Compositions F Through K Component Concentration

Composition	DI Water	Second Abrasive	First Abrasive	Stir	Add Oxidizer	Stir
Composition F	8 grams	0.5 grams Laponite	12.5 grams	2 hours	79 grams of Oxidizer "A"	> 20 min.
Composition G	8 grams	0.5 grams Darvan C	12.5 grams	2 hours	79 grams of Oxidizer	> 20 min.

					"A"	
Composition H	8 grams	0.5 grams Ludox TM50	12.5 grams	2 hours	79 grams of Oxidizer "A"	> 20 min.
Composition I	8 grams	0.5 grams EtCarbonate	12.5 grams	2 hours	79 grams of Oxidizer "A"	> 20 min.
Composition J	7.5 grams	1.0 grams Succinic acid	12.5 grams	2 hours	79 grams of Oxidizer "A"	> 20 min.
Composition K	3.5 grams	5 grams CR140 (20% wt)	12.5 grams	2 hours	79 grams of Oxidizer "A"	> 20 min.

The following table sets forth the pH, settle down time, Ir removal rate and Ir:TEOS selectivity for Compositions F through K.

pH, Settle Down Time, Ir Removal Rate and Selectivity for Compositions F Through K

Composition	pH	Settle Down (ml/min or ml/hrs)	Ir Removal Rate (A/min)	Selectivity
Composition F	7.3	9ml/10 min	240	2.7:1
Composition G	7.3	9ml/10 min	340	2.1:1

Composition H	7.3	9ml/10 min	240	3.9:1
Composition I	7.3	9ml/10 min	350	2.3:1
Composition J	6.7	5ml/2 hrs	80	1:1.3
Composition K	6.9	10ml/10 min	230	3.4:1

The above CMP processes for Compositions F through K were carried out on an IPEC 576 polisher using a Thomas West XY pad and each was achieved by applying a down force pressure of 4 psi, a back pressure of 0 psi, a table or platen speed of 200 rpm, a carrier speed of 18 rpm, and a composition flow rate of 150 ml/min. Compositions F through K were stirred thoroughly before and during their use.

IrO₂ Polishing Compositions

Composition L (IrO₂)

One preferred Iridium Oxide (IrO₂) polishing composition pursuant to the present invention ("Composition L") is comprised of an alpha-alumina abrasive, Hydrazine (NH₂-NH₂*H₂O), and de-ionized ("DI") water. One example of component concentrations for Composition L is shown in the following table.

Composition L Component Concentration

Component	Component Concentration
Alpha-Alumina Abrasive (CR30)	2 wt%
Hydrazine	0.1 mol/1kg
DI Water	Remaining weight amount to obtain final desired amount of

table or platen speed of 200 rpm, a carrier speed of 18 rpm, and a composition flow rate of 150 ml/min. Composition N was stirred thoroughly before and during its use.

Composition N, when employed according to the above process, provides a Pt removal rate of 131 A/min and a BPSG removal rate of 180 A/min thereby resulting in a Pt:BPSG selectivity of 1:1.5. **(Bob what is BPSG?)**

Composition O (208)

Another preferred composition pursuant to the present invention ("Composition O") comprises an alpha-alumina abrasive, Periodic Acid (H_5IO_6), Ammonium Chloride (NH_4Cl), and de-ionized ("DI") water. One example of component concentrations for Composition O is shown in the following table.

Composition O Component Concentration

Component	Component Concentration
Alpha-Alumina Abrasive (CR30)	2 wt%
Periodic Acid	0.1mol/kg
Ammonium Chloride	0.1 mol/kg
DI Water	Remaining weight amount to obtain final desired amount of Composition O

pH Ranges

The present composition may have a general pH range of about 1.2 to about 1.8 and a preferred range of about 1.6.

Preparation

Generally, Composition O is prepared by first preparing a container of DI water to which the alpha-alumina abrasive (CR30) is added. Next, the Periodic Acid (H_5IO_6) is added. Then the Ammonium Chloride is added. Composition O is preferably continuously stirred within the container during at least the composition preparation.

CMP Process:

The following table shows one example of the mixing ratio, process, pH, removal rates and selectivity for Composition O.

Mixing Ratio, Process, pH, Removal Rates and Selectivity

Mixing Ratio	Process	pH	Pt Removal Rate (A/min)	Removal Rate (A/min) BPSG	Pt: BPSG Selectivity
2 wt% Alpha-Alumina Abrasive 0.1mol/kg Periodic Acid 0.1 mol/kg Ammonium Chloride DI water	2/200/18/150	1.6	443	56	8:1

The above CMP process for Composition O was carried out on an IPEC 576 polisher using a Thomas West XY pad and was achieved by applying a down force pressure of 2 psi, a

table or platen speed of 200 rpm, a carrier speed of 18 rpm, and a composition flow rate of 150 ml/min. Composition O was stirred thoroughly before and during its use.

Composition O, when employed according to the above process, provides a Pt removal rate of 443 A/min and a BPSG removal rate of 56 A/min thereby resulting in a Pt:BPSG selectivity of 8:1.

Composition P (208a)

Another preferred composition pursuant to the present invention ("Composition P") comprises an alpha-alumina abrasive, Periodic Acid (H_5IO_6), Ammonium Chloride (NH_4Cl), and de-ionized ("DI") water. One example of component concentrations for Composition P is shown in the following table.

Composition P Component Concentration

Component	Component Concentration
Alpha-Alumina Abrasive (CR30)	6 wt%
Periodic Acid	0.1 wt%
Ammonium Chloride	0.1 wt%
DI Water	Remaining weight amount to obtain final desired amount of Composition P

pH Ranges

The present composition has a preferred pH range of about 1.5 to about 2.0.

Preparation

Generally, Composition P is prepared by first preparing a container of DI water to which the alpha-alumina abrasive (CR30) is added. Next, the Periodic Acid (H_5IO_6) is added. Then, the Ammonium Chloride (NH_4Cl) is added. Composition P is preferably continuously stirred within the container during at least the composition preparation.

CMP Processes:

The following table shows several examples of the processes and removal rates for Composition P.

Processes and Removal Rates

Process	Pt Removal Rate (A/min)
2/200/18/70	220
4/200/18/70	470
6/200/18/70	750
7/200/18/70	1,020

The above CMP processes for Composition P were carried out on an IPEC 576 polisher using a Thomas West XY pad and were achieved by applying a down force pressure of 2 psi, 4 psi, 6 psi and 7 psi, respectively. All processes were achieved by applying a table or platen speed of 200 rpm, a carrier speed of 18 rpm, and a composition flow rate of 70 ml/min. Composition P was stirred thoroughly before and during its use.

Composition P, when employed according to the above processes, provides Pt removal rates of 220 A/min, 470 A/min, 750 A/min, and 1,020 A/min, respectively.